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The American Biology Teacher

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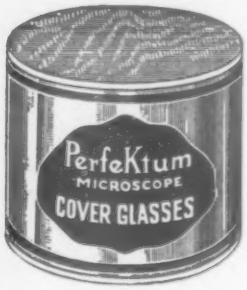

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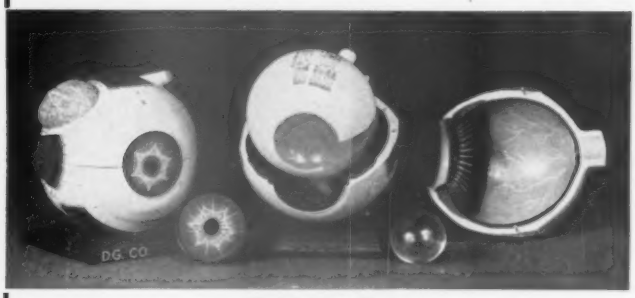

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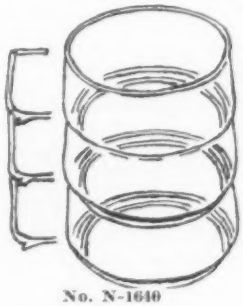

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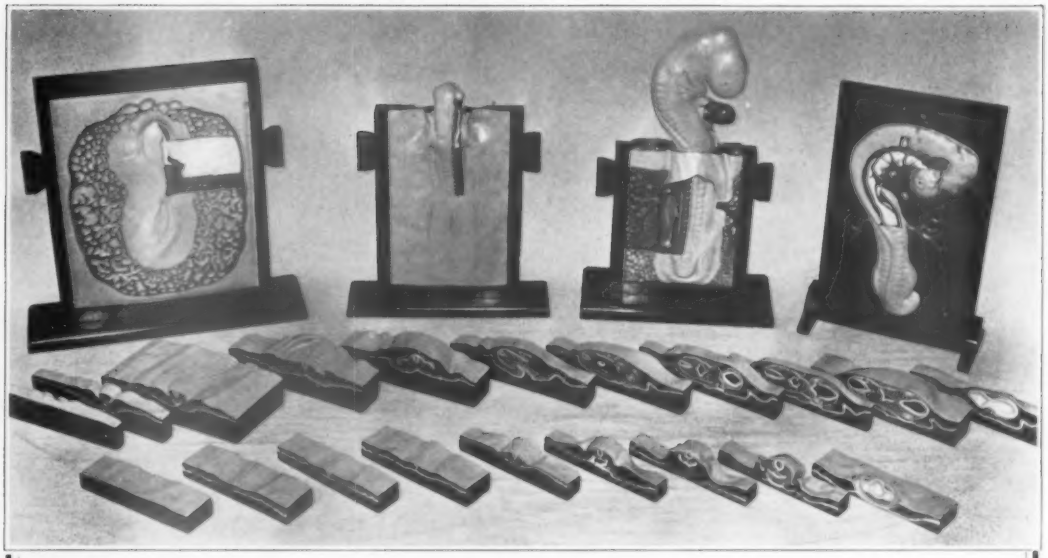

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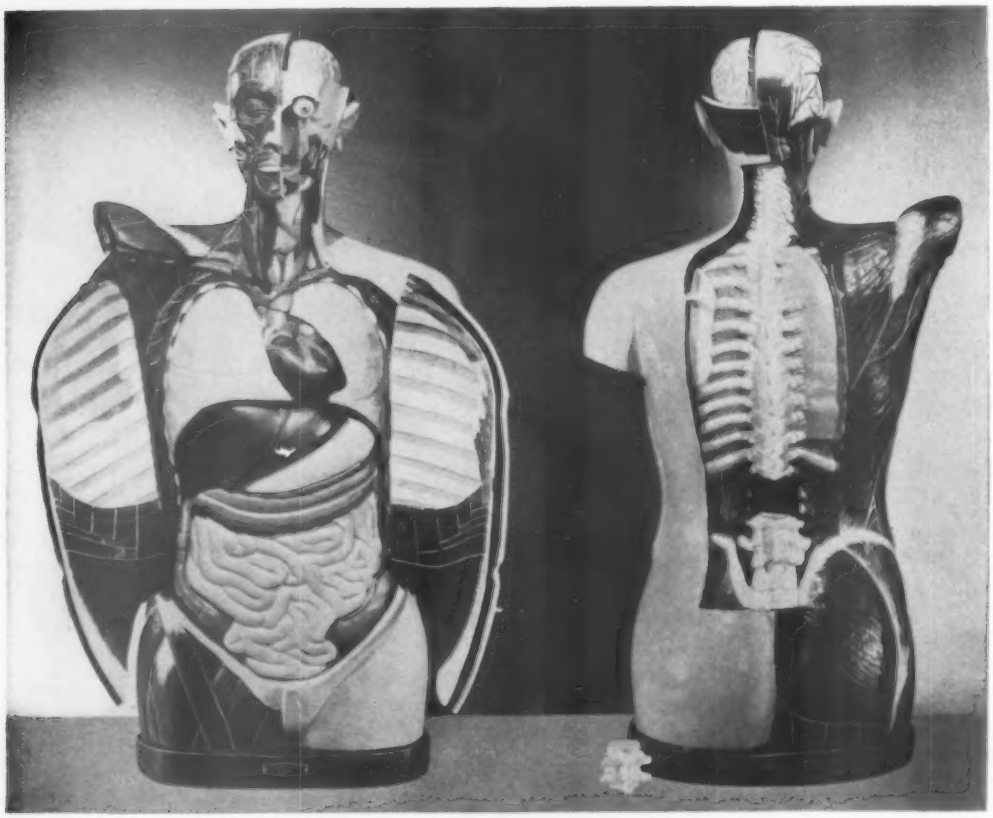

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The American Biology Teacher

Vol. 3 FEBRUARY, 1941 No. 5

Preliminary Impressions and Facts From a Questionnaire on Secondary School Biology[1]

DR. OSCAR RIDDLE
Department of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, Long Island, N. Y.

In December 1939 and January–February of 1940 the Committee on the Teaching of Biology of the Union of American Biological Societies, through its representative, Dr. D. F. Miller, mailed approximately 15,000 questionnaires to teachers of biology in secondary schools throughout the United States. From such teachers 3,186 returns have provided much information which will soon be fully analyzed, assembled and published under committee auspices. The expense of the investigation has been borne by a grant from the Carnegie Foundation for the Advancement of Teaching. THE AMERICAN BIOLOGY TEACHER assisted in publicizing the need for this study, and the members of the National Association of Biology Teachers provided more than their share to the large number of returns which alone could give value to this survey. It therefore seems proper that the first impressions concerning what has been thus learned of biology teaching and teachers should be submitted to the N.A.B.T. and to its official Journal. It is thought, however, that this thumb-nail sketch of the results—though supported by no tabular or graphical data—will prove of value and interest to biologists and educators generally and perhaps to others.

First of all it is notable that the teachers who replied gave data for schools which enroll more than 3,000,000 secondary school pupils, and that the total number of biology teachers now teaching in those schools is approximately 7,686. It is thus evident that although replies

[1] Paper given before the Third Annual Meeting of the National Association of Biology Teachers, Philadelphia, December 30, 1940.

were received from only about one-seventh of the high school biology teachers of the country those teachers gave data for schools in which approximately one-third of all such teachers in the United States are employed. We must therefore regard the data obtained as sufficient to provide much trustworthy information relating to biology in the average or better than average high schools of this country. The method of mailing the questionnaire makes it unlikely that the smallest and poorest schools were reached to an extent commensurate with their numbers. Only 2.7% of the replies were from non-accredited high schools.

Amount of biology taught. High interest attaches to information concerning the total amount of various biological subjects available to high school pupils in various schools throughout the country. In the following statements that portion or percentage of the "general science" course which is biological science has been properly credited to biology. The "hours" given are 60-minute hours per week for one year.

For the public schools in a group of 11 "large cities" of the United States the replies received indicate that least biology is offered (it is of course not necessarily taught to all pupils) in Milwaukee (5.7 hrs. per wk.), Boston (6.6 hrs.) and St. Louis (7.2 hrs.). New York City schools were suffering a definite reduction in their biology offerings (7.9 hrs.) during the precise time required for completion of this survey; at the present time the probable offering (7.0? hrs.) of New York City is less than that of the average high school of the United States (7.3 hrs.) and about 30 per cent less than the average amount offered (10.1 hrs.) by all cities (excluding the 14 specifically named in this and the next following paragraph) of more than 100,000 throughout the U. S. Largest offering of biological subjects in this group of large cities is indicated in Kansas City, Mo. (18.8 hrs.), Washington, D. C. (16.5 hours.), "California" (15.3 hrs.), and Seattle (14.8 hrs.). Too few returns were obtained from Providence, Baltimore and New Orleans to warrant their classification in this report.

The geographical region which seems to offer least biology in its public schools is New England (6.7 hrs.). Next follow, in order of increase, the Southern (6.9 hrs.), Middle Atlantic (7.1 hrs.), Central (7.2 hrs.) and Western (9.1) states. The individual states with indicated lowest offerings in biology are Vermont (4.2 hrs.), Rhode Island (5.1 hrs.), upstate New York (5.6) and Maine (5.7 hrs.); those offering most, Utah (12.1 hrs.), California (10.3 hrs.), Missouri (10.2 hrs.) and Idaho (10.0 hrs.). It is especially notable that Milwaukee, Boston and St. Louis all offer less of biological science to their pupils than do the remaining schools of the states in which they are located. These values are: Milwaukee, 5.7, other Wisconsin, 5.9; Boston, 6.6, other Mass., 7.4; St. Louis, 7.2, all other Missouri, 10.6. How much the offering of these three cities differs from that of other large cities is indicated by the following comparisons: The average offering in seven large cities (New York, Philadelphia, Chicago, Washington, Detroit, Minneapolis, Seattle) is 11.1 hrs. Again, if all of the 11 cities which have been mentioned above (and also Baltimore, New Orleans and Providence) be excluded from consideration all other public high schools offer an average of 7.2 hours of biology weekly for 1 year; and, excluding the 14 cities hitherto named, all other cities of the U. S. with populations in excess of 100,000 offer an average of 10.1 hrs. of

biological science.

Thus one would especially wish to know just what conditions or forces are responsible for the marked restriction upon the offering of biological science in the public high schools of Milwaukee, Boston, St. Louis and present-day New York. Also, in upstate New York—whose near-minimum offering is outdone only by Vermont and Rhode Island.

On the basis of school samples obtained in this questionnaire, private schools (149) apparently devote slightly more hours (7.6) to biological science, and parochial schools (80) definitely fewer hours (6.0) to biology than do (2,166) public schools (7.3 hours).

In a consideration of the amount of biology taught in our schools two additional items are of outstanding interest. First, 11.6% of 2,472 teachers reported that in their schools a "social study has displaced a biological study during the past 5 or 10 years." Second, 19.8% of 2,581 teachers similarly report that in their schools a biological subject or unit was transferred to the teacher of physical education during the past 5 or 10 years.

The trends and tendencies thus clearly indicated by the figures just supplied by our high school teachers would seem sufficient to rouse action in all those who may stress the importance of biology in the education of a modern people. One wonders whether high school biology teachers and the many members of biological departments of our colleges and universities will forget and ignore both this continued threat and this clear evidence of a defeat and failure!

Frequency of various biological subjects in curriculum. For 11 states selected from all sections of the country the relative frequency of various biological subjects in the secondary school curriculum was learned. Though there is some variation among the several states in the frequency with which physiology and hygiene is offered, it is clear that "biology" is offered far more frequently than all other subjects put together and that general science—though far less frequent—comes second to biology. This order is found to hold for every one of the 11 states included in this particular summary. The 805 informants report: Biology, 742; general science, 275; hygiene, 69; botany, 42; zoology, 25; physiology, 47; and a total of 8 variously named additional courses.

This item of information, of course, was already available from other sources, and very many people know that though courses in zoology and botany were the usual offerings of twenty-five years ago those subjects have meanwhile been superseded by biology and general science. But here one is tempted to ask: How generally have college departments of zoology and botany recognized—and provided for—this considerable shift in the training needs of our only body of teachers who have opportunity to teach biology to our people? By way of answer it can be said that we all know that some college departments have at least partially adjusted their course offerings to the newer needs. But a host of high school teachers now utilize the opportunity offered by this questionnaire to say plainly and directly that their college courses in botany and zoology did not at all provide them with the subject matter which is essential for them as teachers of biology in high schools. This word comes from those who have begun their teaching within the last 3 years perhaps as forcefully as from those who left college 10 or more years ago; and it comes from teachers in every section of the country.

Details of this emphatic verdict of our

high school teachers must await the fuller publication of these results; but it is painfully clear that if the biological departments in most colleges and universities regard the teaching of biology to a nation as a part of their function—and one which they would care to perform well—they will need to find more effective means of teaching biology to prospective teachers in our high schools. For those already teaching only well-planned summer laboratory and field courses can supply the type of instruction usually requested. Will American biologists increase and improve present opportunities for such training?

Amount of laboratory work. For 12 states which represent all sections of the country details concerning the average amount of laboratory work done in the various biological subjects are available. Since the very great majority of such classes are for "biology" and the next greatest number are for "general science" the present remarks will be limited to laboratory and recitation time in those two subjects. In all of these 12 states less laboratory time is devoted to general science than to biology. In the biology course least laboratory time is recorded by Massachusetts (1.2 hrs.); New Jersey (1.4); and Virginia (1.6); most by Texas (2.6); Louisiana (2.1); Ohio (2.0) and California (2.0). Intermediate and nearly equal amounts are recorded for the other five states: Indiana (1.9); Alabama (1.9); Oregon (1.9); Kansas (1.7) and Idaho (1.7). The laboratory work in general science follows a somewhat similar pattern with least in Massachusetts (0.75 hr.); Alabama (1.1); Indiana (1.3); Kansas (1.3) and Idaho (1.3), and with most in Texas (2.6); Ohio (1.9); Virginia (1.7) and New Jersey (1.7). When all biological subjects are considered it is found that the greatest amount of laboratory time is given by the high schools of Texas, Ohio and California and least in Massachusetts, Idaho and Alabama.

It is evident that in many schools biology is not taught as a laboratory science though it is so taught in most schools. This summary contains the suggestion that the displacement of biology by general science practically involves not merely the teaching of less biological subject matter but a partial shift away from a laboratory science subject.

Field trips. A total of 1,774 teachers (of 3,186) indicate that their classes take one or more field trips. 49.1% (1,425) of the public school teachers stated the actual number of field trips taken in their biology course, and the average number of trips for this portion (about half) of the public schools is 6.4 per year. This number differs markedly in different states. Smallest numbers belong to Nebraska, 3.8 (18 replies); Indiana, 3.8 (68 replies), and Montana, 3.85 (12 replies); largest averages are reported by Florida, 12.6 (11 replies); Tennessee, 9.2 (18 replies), and Iowa, 8.9 (30 replies). The average number of trips is fairly uniform, however, for the different geographical regions, although the percentage of teachers who specify the number of trips differs geographically. Thus, New England, 5.8 trips for 38% of replies; Middle Atlantic, 6.2 trips for 39%; Western, 6.2 trips for 45%; Central, 6.5 trips for 54%; Southern, 6.7 trips for 62%.

Obviously this important way of teaching biology requires some special training of the teacher, and many teachers earnestly ask that colleges and universities provide special courses and facilities for such training.

Teacher preparation for teaching biology. Some facts relating to the amount of college credit (average num-

ber of hours) in biological science received by teachers in various types of public schools, and in the different geographical regions of the United States, are of interest here. With one notable exception—that of teachers in cities of more than 100,000—the teachers of New England appear to have less college training in biology than do those in any other section of the country; and it was noted above that the schools of New England offer the smallest amount of biology to their pupils. The average amount of college training (in hours) received by teachers in all types of public schools of various regions is as follows: New England, 29.7; Southern, 32.4; Middle Atlantic, 35.7; Central, 38.7; Western, 43.5. It is notable that the order in which the geographical regions are named here is precisely the same order they assumed above when their place in the series was determined by the amount of biology which the high schools offer their pupils. It thus appears that the smaller the amount of biology in the school curriculum the less well prepared is the teacher to teach that minimum. Teachers in the "large cities" of New England have more college training (57.2 hrs.) in biology than do teachers in "large cities" of any other section, though teachers reporting from "small cities" (10,000 to 100,000) in the Western states have equal or more college credit (59.0). Among the rural schools of the country the teachers of New England have least (19.6 hrs.) college training and those of Western states have most (36.5 hrs.).

Only 53% of teachers replying (2,931) to this item say that their "special preparation" was for teaching biology. It is therefore interesting, and seemingly complimentary to the subject, to find that with free choice of subjects 70% of 2,764 teachers say they now prefer to teach biology.

The following information was obtained concerning the highest college degree held by biology teachers. In public schools we find this to be, bachelor, 49%; master, 38%; doctorate, 1.2%. In parochial schools these values, respectively, are: 54%, 27% and 1.0%; in private schools, 36%, 42% and 4.9%. In fields of *biological* science these groups of teachers have college credit in the following average amounts: Public, 37.6 hours; parochial, 30.1 hours; private, 33.8 hours.

Those biology teachers who have done *graduate* study indicate that such study was 41.2% biology; 14.7% other sciences; 32.6% professional education; and 9.8% other subjects. Nearly 69% of all teachers indicate they have taken at least one course in biological science in the graduate school. Of the 2325 replies to the question relating to this topic 92% indicate that teacher training of the biology teacher should include more training in subject matter; 8% speak for less training in subject matter.

On the subject of their own training very many teachers comment on the need for laboratory and field courses (college) in which the prospective high school teacher may learn *how* to present biology to students. In impressive numbers also they stress the view that biology teachers need to be fairly familiar with several related sciences. They frequently criticize both the large quantity and poor quality of the courses they took in "professional education."

Teacher memberships in professional societies. A total of 2772 (of the 2900) teachers in public high schools noted their membership in one or more professional organizations. An attempt has been made, often merely on the basis of the name of the society, to classify these memberships into "educational," "sci-

entific" (other than N.A.B.T.) and to note the number of N.A.B.T. memberships. As thus done this large group of teachers averages 1.8 memberships in educational and 0.55 memberships in scientific societies other than N.A.B.T. The 596 N.A.B.T. memberships provide an additional average of 0.22 memberships for the teachers reporting on this item and it thus appears that already this organization has much increased high school teacher memberships in "scientific" societies. States showing lowest average memberships in professional societies were Arkansas, North Carolina, and Florida; highest were Maine, New York and New Jersey. Only in New York did memberships of teachers in scientific societies equal those in educational societies.

From other sources we know that little more than one-tenth of the nation's teachers of secondary school biology are as yet members of the N.A.B.T. And the data of this survey indicate that, apart from the N.A.B.T., only about one-half of our public school biology teachers belong to any scientific association.

Stray items among many items: Only 68.9% of teachers utilize rooms specially arranged for biology (some unprepared rooms even in Philadelphia, New York, Chicago, St. Louis, etc.).

For 39.4% of biology teachers extra-curricular school activities interfere "much," or "seriously" with teaching.

Among the 110 schools of upstate New York from which questionnaires were returned 3 report "no biology taught." This is one in 37!

From public schools of all cities of more than 100,000 50.6% of teachers report that the average size of their classes in biology and general science is in excess of 34 pupils per class. For cities of 10,000 to 100,000 this value is 26.5%.

In Philadelphia all of 13 teachers, or 100%, report such oversized classes; and 92.3% of these average more than 40 pupils per class. In New York City 96% (96 of 100 replies) of classes are oversized. In Minneapolis 83.3% and in Detroit 80% of classes are oversized. In schools (3) of large cities of Rhode Island 100% of the classes in biology and general science exceed 34 pupils.

For all schools represented by these replies sex education was listed (in the numbers indicated) as a definite goal of instruction in classes in general biology (1,197), hygiene (461), physiology (215), botany (44) or another department of instruction (311). No such instruction is offered in schools reported upon by 959 teachers.

The method adopted for rating the equipment of the rooms where biological science is taught classifies 1210 as good, 866 as fair and 994 as poor.

In the present sample of all schools of the U. S. the course in general science is about 23.8% biology. Of those teaching this subject 34% were specially trained in biology, 32% in chemistry, 23% in physics, 4% in geology and 7% in other subjects.

Men returned twice as many questionnaires for this summary as did women—2,115 to 1,045.

Textbooks are most often selected by the teacher making the reply (1,124); next in frequency, by a committee of biology teachers (540), another teacher (495), the state (404), a superintendent (375), a principal (319), a city (216), a curriculum committee (130), a county (93).

The average length of class periods in the schools reported is 50.6 minutes. In many large cities this period is only 40 to 45 minutes.

The genetic inequality of human individuals is taught in the classes of 2,370

of those who reported, and in some other biology or social study course in these same schools in 445 cases. It was not personally taught by 440 teachers, nor in 320 of the schools reported.

Though about one-third of all biology teachers (and pupils) are represented in the schools reported only 523 "biology" (and 331 nature study, 151 bird study) clubs are listed for these schools.

The biology teachers who supplied these data had an average teaching experience of 11.3 years.

Textbooks in use in all public schools are unsatisfactory to 27% of teachers. Of 242 teachers in 9 separately summarized large cities 46.6% say the text in use is unsatisfactory.

The "graduate" training of biology teachers in rural schools of Michigan was 10.0% biology and 39.6% professional education. Rather similar travesties on "teacher-training" are encountered extensively throughout the United States.

Teaching and not teaching organic evolution. The question on this item was so subdivided as to facilitate the recording of fairly accurate information with a single check mark. It is notable, however, that 111 teachers omitted such a mark on this question and that only 1,457 teachers—or somewhat less than 50% of those who did make one or another reply to the question—indicated that they teach evolution as "the principle underlying plant, animal and human origin."

A next following item asked those who avoided or lightly considered the subject of evolution in their teaching to record the main sources and reasons for opposition to it. Only 73 acknowledged restraint "by action of our state legislature." Of the seven different brackets used for recording groups or types of opposition the highest single number, 285, represented those who found the subject "opposed by a majority in our community." For the several brackets the ultimate objection is clearly that of religion. The bracket for "opposed by my personal belief" was directly checked by 233; and 216—only partly included in this group of 233—used a line or two to write specifically of their personal aversion or opposition. Approximately one in ten teachers who replied to the questionnaire did not hesitate to record their "personal unbelief" in the principle of organic evolution. There is reason to think that many others with the same view did hesitate thus to record themselves

Any further analysis and all except a single word of comment on this discouraging information is deferred until full and final publication of these results. Biology has a Fifth Column of no mean proportions.

Topics teachers would emphasize. Teachers were asked to list the 4 or 5 topics on which they would place most emphasis in a high school course in "general biology." From one-third of the total number of questionnaires returned—from 15 states representing all regions of the U. S.—these topics for emphasis have been classified, counted and tabulated. Approximately 3,000 entries or topics were thus set down by 866 of the 1,088 teachers of these 15 states. Excluding such items as "animals," "botany," "biology"—which were set down with surprising frequency—only about 21 topics were stated 13 or more times, though hundreds of different topics (including stars, planets, neatness, posture, hobbies, fertilizers, pollination, pets, etc.) were mentioned one or more times for a total of many hundreds. Topics most frequently listed were: health-disease-hygiene (397), physiology (263), heredity (192) and genetics (90), conserva-

tion (127) and structure (102). The least popular among these 21 major topics were photosynthesis (13), biological principles (13), scientific method (21), behavior (29), adaptation (37) and evolution (39). Somewhat more popular than the latter group of subjects were insects (53), nature study (87) and taxonomy (88).

Though the very large amount of highly informative material obtained on this item shows that many biology teachers throughout the country have a sound grasp of their obligation and opportunity to teach a science, the data as a whole also clearly show widespread tendencies to teach biology not as *science* but (a) as paths to pleasing hobbies or (b) as a series of practical technologies. These tendencies involve and raise several serious questions.

The criticism implied in the statement just made—on the teaching of biology as "a series of practical technologies"—should be clarified, though this is done solely in terms of personal opinion of the writer. It may be highly desirable—the writer thinks it is—to teach high school pupils very much of the very practical in hygiene, in conservation, in nutrition, in animal husbandry, in sanitation, or in economic biology, etc. But even if this be granted there are two cogent reasons why no one, or any group, of these applications of biology should become dominating interests during the first one or two years which a high school pupil devotes to biological science. First, when taught as a science the contribution of biology to the education and mental discipline of an educable pupil is incomparably greater than when taught as a smattering of its applications. Second, the biological technologies will hang more superficial than his skin on any pupil smeared with them prior to an introduction to the basic facts which relate and anchor them. This principle is and has long been axiomatic on the college and university campus for training in technologies of every sort—medicine, engineering, forestry, and the rest. Everywhere the rule is, the basic sciences first; applications afterward. Unless or until educators and school administrators comprehend this principle our secondary school biology will be a happy hunting ground for whims and fads and so-called "useful knowledge." We can get quite properly to an excellent lot of "practical applications" in a third or fourth year of biological instruction in the secondary school.

After-image and retrospect. Data submitted by 3,200 teachers of biology in our high schools give clear evidence of a considerable body of well-trained biology teachers, professionally minded, alert to the best that the biological sciences offer to their immature pupils. Perhaps, however, it is too much to expect a flattering result from the teaching of a very complicated science to a nation when only 53% of the teaching group made "special preparation" for teaching that science. Indeed, this fact is especially discouraging and serious, when only 69% of those thus trained, and not trained, may teach in rooms specially provided for the subject; when only 39% of rooms have good equipment; when 26.5% of classes are oversized; when 27% of textbooks are unsatisfactory; when class periods are often reduced to 40 to 45 minutes; when field trips are either entirely omitted or taken in small numbers; and when about 40% of these teachers have extracurricular school activities which interfere much or seriously with their teaching.

Equally notable and serious are the restricted offerings of the subject in certain large cities and in entire states; the counterbalance of occasional gains in the

curriculum by widespread, if slow, current displacement by other subjects; and, a fringe of high schools in which biology is either still an undiscovered subject or a forgotten one. Again, it is the grief of this subject that it is still pursued by long shadows from the Middle Ages, shadows screening from a people what our science has learned of human origin and destiny —a science sabotaged because its central and binding principle displaces a hallowed myth on the origin of man. Finally, the sum of these difficulties and partial frustrations—reinforced strongly no doubt by present unparalleled overflow of mentally restricted pupils into high school classes—seems unfortunately to be leading many high school teachers to abandon the teaching of biology as *science* and to drift with softness and ease into either the lullaby of hobbies or the smug acceptability of the practical.

But action and repair, advance and betterment, are the most legitimate offspring of this effort to take stock and learn. The new information should provide some sound bases for improvement. Will those who have either obligation or opportunity do their share? Will plans and action start at once and in many places? Though the high school teacher and his product are the things immediately involved, it is clear that his principal and school administrators, his city and state, his guides in professional and science training, must all find and contribute something that is essential to successful teaching of this science.

The writer acknowledges the invaluable assistance rendered by Leona Lewis Riddle in summarizing data described in this paper.

The Training of Biology Teachers

MARY D. ROGICK
College of New Rochelle, New Rochelle, New York

The teaching profession, because of its very nature, its importance to the nation, and the large number of actual and prospective candidates for it, has a right to demand a high degree of training, scholarship, and fitness from its members. The training of a teacher, whether it be for high school or for college teaching, should be especially thorough in the major field of the candidate.

To those who have been in the teaching profession for any length of time comes the realization that an instructor must know a great deal about his subject in order to do justice to the teaching of that subject. The science teacher in particular soon becomes conscious of any deficiency in training: he may find that he needs a larger number of laboratory techniques, methods, experiments, and practical experience in teaching.

Biologists have in addition a number of special problems related to the nature of their subject-matter. Some of these are suggested in the list below. The biology teacher should have some training in each of the topics mentioned; institutions engaged in the training of teachers can do a great service by attempting to train the candidates in as many of these divisions as fall within their scope:

1. Use of the microscope and its accessories.
2. Operation of various instruments and machines.
3. Preparation of necessary solutions.
4. Preparation of microscope slides.
5. Preparation of visual aids.

6. Handling and care of living things in the laboratory.
7. Field work.
8. Fundamental facts, principles and theories.
9. Research.
10. Teaching techniques.

I should like to discuss briefly the content of each of these divisions.

Use of the Microscope and its Accessories

It is surprising how many biologists and graduate students do not know the potentialities of their microscope and its various attachments: the camera lucida, micrometers, illuminating devices, prisms, filters, different objectives, etc. If information on these cannot be obtained from the various courses which a student takes, then a special course should be organized where careful training in the use and care of the microscope and its numerous attachments and accessories is given.

Operation of Instruments and Machines

In teaching, it sometimes is necessary to know about the operation or use of various machines and instruments, as film and slide projectors, microtomes, kymographs, autoclaves, centrifuges, manometers, balances, and micromanipulation apparatus. Of course, it is readily understood that the average biologist is not familiar with several of these mechanisms. However, that situation is easily remedied by the taking of suitable courses (microtechnique, physiology, bacteriology, bio-chemistry, cytology, etc.) during the summers or at other times. In such courses he will very likely make use of these instruments.

Preparation of Solutions

The preparation of various solutions which are used in biological courses sometimes falls to the lot of a teacher. These solutions may be preservatives, stains, culture media, standard solutions, indicators, and so on. To a certain extent the technique can be learned simply by following directions which are given in various laboratory manuals; but a course in chemistry, microtechnique or bacteriology fortifies one considerably against any difficulties that may arise in following these directions.

Preparation of Microscope Slides

Knowledge of how to make histological, cytological, or bacteriological slides for microscopic study is more or less of a necessity for a biologist, if for no other reason than to lead him to an appreciation and a thorough understanding of the various preparations his classes use.

Preparation of Visual Aids

A fascinating phase of teaching is the preparation of such visual aids as are of interest or value in one's field: charts, lantern slides, photographs, diagrams, drawings, posters, mechanical gadgets, or simple mechanisms.

A biologist who has a camera and who knows how to get the most out of it is a fortunate individual, for he can build up a great amount of interesting and original visual material for his classes. A little training, either formal or as a side-line or hobby, in elementary photography, developing, lantern slide preparation, and drawing techniques (ink, water color, oils, etc.) is a good thing for the candidate who intends to teach biological subjects. I have seen lantern slides and photographs prepared or taken by biologists which were not only excellent from the technical view-point but were splendid source material for ecological,

geological and naturalist lectures. The use of this material need not be restricted to the classroom, but may be extended to clubs and small informal groups. Incidentally, for those who are camera enthusiasts, the biological stations offer a golden opportunity to photograph wildlife in its natural setting, and also to get many forms which might be inaccessible if one were to depend upon his own resources and initiative rather than upon those of the station.

Because so much of biology is dissection, observation of structures and processes, demonstration and experimentation, the need for a knowledge of a few drawing principles and techniques (types of pens, papers, tracing and drawing devices, etc.) is definitely felt by many biologists, whether they be teachers or research men.

Care of Living Things in the Laboratory

Each instructor at some time or other is faced with problems centering around the handling, care, or raising of living things in the laboratory, whether they be bacteria, plants, or animals. In order to acquire techniques for the care and growth of bacteria one should take a suitable course in bacteriology. The problems of maintaining different kinds of plants—whether they be microscopic and grown in aquaria or in various culture media, or larger and grown in pots and beds—are not always suitably covered in ordinary botany courses, but may be learned through practical experience, observation, research, or while serving as an assistant in the botany department of a large institution. Also, local nurseries can be of great help here.

The larger animals commonly kept for laboratory use are the fishes, amphibians, reptiles, mice, rats, guinea pigs, rabbits, and cats. The smaller animals which one may have occasion to grow or keep in the laboratory are Protozoa, snails, arthropods (crustacea and insects), flatworms, and miscellaneous invertebrates. Sometimes, studies in high school or beginning college courses will bring in an animal (snake, opossum, squirrel, etc.) and the instructor will be faced with the problem of what to do with it or how to care for that particular specimen. Hence the need for some training along the lines of health, growth and food requirements, care of young and mature animals, and the eradication of pests and parasites. This training comes less from general biology courses than from practical experience, observation, or participation in research projects, or from assisting in a department where experimental laboratory animals are maintained.

Field Work

One of the most vital and interesting parts of a biological course is the field work. No matter how many laboratory courses a biologist has had, his biological training is still incomplete if he has never had a field course at some biological station. Some schools and universities have realized this and have required or strongly urged their students (graduate and undergraduate alike) to attend such a station.

A biologist should know where he can get or collect living things for his classroom, and after he has collected them he should know or find out how to care for them. This involves a knowledge of taxonomy, biota, physiology, ecology, natural history, and to some extent the geology of a region. He should be informed on some common species of plants or animals which are to be found in the immediate vicinity or region where he is being trained or where he is teaching. For example, he should

know those forms which may be found along the seashore, in salt water, in fresh water (ponds, streams, rivers), in or on land (meadows, caves, mountains, deserts, forests) and in other habitats. This type of information is most valuable to the biologist and makes a deep impression on those who come in contact with him. It is sometimes said of a biologist that he knows too much about things in books and in the laboratory and not enough about those in the great outdoors (natural history, ecology and practical geology). The quickest way to acquire this information effectively and pleasantly is by summer attendance at a biological station. (For a description of the stations in this country, with a list of the types of work offered in each, see THE AMERICAN BIOLOGY TEACHER for March and April, 1940.)

Attending one of these stations is a sure and enjoyable way to learn about wildlife, ecology, or geology of a region. Biology does not begin to take on real color or meaning until one has spent some time at such a station and has done some collecting and observation of species in their normal habitats.

The type of material one learns at such stations is very practical, for example one may find out: how a field trip is conducted; what supplies are necessary on a field trip; the care needed in keeping these supplies in good condition; the names and distinguishing features of a number of species of plants and animals; exactly where they may be found; under what ecological conditions they exist, survive, or thrive; the normal activities of these species; what happens when these normal activities are disturbed; how to collect and handle various specimens; what to do with them after collection and how to care for them in the laboratory; how to preserve them; how to experiment with them; numerous techniques or pointers on the study of development, dissection, anatomy, physiology and behavior of hitherto unfamiliar forms; what types of research are being carried on at that station by veteran and beginning investigators and what research problems remain still to be worked out.

There is much else to be said for the value of attending a biological station. For one thing, it is an excellent way to combine a vacation with a study schedule, since very frequently a large part of the work is out-of-doors and under very informal conditions. One is away from a great number of disturbing city-life influences and distractions and can work or study in peace and quiet under ideal conditions, in pleasant surroundings and with scientists who have the same interests but who come from all sections of the country. In addition, one may frequently get a number of excellent ideas for research from such a group.

To get the most benefit from a biological station one should have a good background in science courses before coming to such an institution. Inlanders and those who have never been near the ocean have a great deal to learn about aquatic organisms. For them a marine station has much to offer. Even those who have lived near the seashore for a good many years are amazed at the amount of either misinformation or ignorance which they had harbored until they took a course or two at a marine station. A biologist should try, if at all possible, to attend more than one biological station in the course of his training (this means after he has begun to teach, during the summers).

FUNDAMENTAL FACTS, PRINCIPLES, THEORIES

It almost goes without saying that a

science student or prospective teacher should know as much as possible about the data, facts, principles, theories, and history pertaining to his branch of science. This knowledge may be acquired in many ways. The most common method is by attending lecture and laboratory courses in various branches of the subject. It is unfortunate that some biologists, once they have obtained their Master's or Doctor's degrees, feel that they have nothing to gain by taking additional courses in summer school or during their sabbatical years. (We assume, naturally, that the courses are sufficiently well organized, have a worthwhile content and are properly taught.) Taking courses is one way that a teacher can keep from losing the student outlook, which is vital to successful teaching, and can gain a large amount of information in a short time, with comparatively little searching or waste of time on his own part. Courses furnish a skeletal framework or outline which can be filled out or augmented later, should the need arise. Incidentally, if at all possible, a biologist should take some of his training in several different institutions so that he has a broader outlook, sees different laboratory set-ups or techniques, and gets a large variety of courses.

Another method of acquiring some of the fundamental facts and principles is by independent study or research, although this way is harder and requires much more time. Constant reading of technical or abstracting journals, books on general or special phases of his particular branch of science, or other sources, is indispensable. Sometimes a well chosen reading list, faithfully followed, will do wonders in providing the biologist with the necessary background.

Still another way is for a prospective teacher or graduate student to obtain a position as laboratory (or research) assistant in a large university, particularly in an institution where a great deal of live material is used and where the assistant has considerable responsibility in setting up laboratory experiments or making preparations for class. Assisting is a most valuable experience, especially if it is carefully supervised and directed by a responsible older member of the faculty who takes the assistants in hand, coaches them weekly or oftener in the work that they are to do, the experiments which they should set up, the techniques involved in managing a laboratory or a class, the grading of papers, and a number of other important details which contribute to the smooth running of classes.

In large metropolitan areas there are a number of organizations, museums, societies, clubs, science academies, and groups of people who are interested in some phase of science—microscopical, ornithological, botanical, general science, chemical, bacteriological, ecological, entomological, parasitological, horticultural—which a teacher may join. Some of these organizations sponsor field trips, exhibits, study groups, lectures, forums, demonstrations and other projects, in addition to their regular meetings. One can learn a great deal from attending these meetings and functions. In addition to these local functions there are national conventions which are very worthwhile and stimulating.

Research

Whenever possible an instructor should be doing research along some line, in addition to his teaching. This applies particularly to college instructors, but should be an ideal of high school teachers as well. A number of excuses are usually offered why many teachers

(Continued on page 177)

INTANGIBLE VALUES OF BIOLOGY

I have just received a letter from a young man—a former student of mine—who is now a patient in a sanitarium for the tuberculous. During the twelve years that passed since I last saw him I had not thought of him once. His letter, however, brings home most forcibly the fact that we as teachers have no way of calculating the final effects of our labors; and it indicates that biology may have enduring cultural values in the lives of our students of which we are not aware. Since the note struck in this communication seems to go beyond any personal message I take the liberty of quoting the letter in full:

"Back in about 1928 or 1929 I was a zoology student of yours at Lindblom High School. You will remember that you gave a 3rd semester of Advanced Zoology one year, which consisted chiefly of the study of Laws of Mendelian Heredity, and which included the breeding of fruit flies in the laboratory. It was my privilege to take this course and it may interest you to know that I have always regarded the fundamentals we learned there as a valuable part of my general education. In the past few years I have had conversations with many young doctors and medical students and have been pleased to find that my grasp of the Mendelian Laws compares favorably with theirs. Your course was a good one, and I am happy to have had the opportunity to have taken it.

"After finishing high school at Lindblom I went into chemical engineering. I worked at this for about six years until last summer when I came down with a mild case of pulmonary tuberculosis. At the present time I am struggling with this in a sanitarium.

"Perhaps you are wondering why I should be writing all this to a Zoologist. It's this:

"Time passes slowly here, even though one does considerable reading. I have become interested in one of those glass enclosed ant nests. You no doubt are familiar with what I mean. They look something like an aquarium, but are much narrower. Only the front and rear panels are glass. The interior is filled with a portion of an ant hill, along with enough ants, workers, queen, etc., to make up a complete nest unit. The top is covered so as to give ventilation but not to allow the ants to escape. The ants build their passageways along the glass panels and afford an excellent opportunity for observation of their marvelous organization.

"One of these would be very interesting to me as well as to some of the other patients here. The only drawback to my idea on this which I can think of is that at night our rooms become very cold, and, I suppose, kill off the ants. Also, as I remember, the ants are dormant in the winter and would not perform.

"As you are the only entomologist I know of, I am asking for your advice in regard to the practicability of keeping such an ant nest in the winter season. Also, can you furnish the name of a biological supply house which sells them?"

Deservedly, this young man will receive a prompt reply, with the advice he desires. It is being suggested to him that he may be able to accumulate observations worthy of being placed on record in published form. But even though his interest in ants as a hobby leads to nothing further than relief from the boredom of his present lot, who can doubt that a little knowledge of biology has in his case paid good dividends? E. C. C.

ELECTION NOTICE

The following nominations have been made for the offices of *The National Association of Biology Teachers* for the year 1941–1942 by the Nominating Committee. An official ballot will be mailed to you soon.

(*Biographical sketches prepared by M. C. Lichtenwalter*)

For President-elect:

Mr. M. A. Russell, Royal Oak, Michigan: present Second Vice President; associate editor of THE AMERICAN BIOLOGY TEACHER; President of the Detroit Biology Club, 1937–1939; past President of the Science Section of the Michigan Schoolmasters Club; President of the Highland Park District of Michigan Educational Association; graduate of Michigan State Agricultural College; M.A., University of Detroit; teacher in the Highland Park Junior High School for the past 24 years.

Mr. Fletcher J. Proctor, Concord, N. H.: a member of *The National Association of Biology Teachers* for three years; contributor to THE AMERICAN BIOLOGY TEACHER and to other scientific publications; organizer of the New Hampshire Association of Biology Teachers and its present president; teacher one year, University of Vermont, seven years in high school, the past four as head of the biology department, Concord Senior High School; holds two degrees from the University of Vermont.

For First Vice President:

Mr. William A. Betts, Austin, Texas: teacher in the Senior High School at Austin; graduate of the University of Texas; has a thesis in process of completion for an M.A. degree from the same institution; member of the Texas Association of Science Teachers and their editor of publications; associate editor and contributor THE AMERICAN BIOLOGY TEACHER; has published articles in other scientific journals.

Mr. W. W. Fulcher, Mobile, Alabama: full time instructor in biology, Murphy High School, Mobile; graduate of Southwestern, 1921; has done graduate work at Peabody College and the University of Colorado; charter member of Mobile Academy of Science and speaker at its meetings.

Miss Ruth A. Dodge, Johnstown, N. Y.: head, biology department, Johnstown High School; A.B., M.S., Middlebury College in Vermont; M.A., Syracuse University; graduate work in several other institutions; member Eastern Zone Science Teachers for 13 years and district representative and member of committee for revision of the syllabus; associate editor and contributor THE AMERICAN BIOLOGY TEACHER; contributor to several other publications.

Miss Eunice E. Sharp, Chicopee Falls, Mass.: instructor in Senior High School with 15 years teaching experience; graduate of Brown University; M.A., Smith College; work in several other institutions; member nominating committee for N.A.B.T., 1939–1940, and a charter member of same; active in the New England Biological Association.

For Secretary-Treasurer:

Mr. P. K. Houdek, Robinson, Ill.: teacher of biology and assistant principal, Township High School; graduate of Knox College; M.A., The University of Chicago; major field of interest social hygiene and sex education on which he has published articles and delivered lectures; President, Illinois Biology Teachers Association for five years.

PROJECTS FOR 1941

It must be apparent to members that in order to continue the low one dollar rate on our magazine we must increase our income at once. This can either be done by increasing our membership or selling material. Therefore I wish to propose the following projects for this year:

(a) Initiate a campaign to put biology into every school in the country; many schools still do not give the regular course in biology. Teachers could report the names of such schools to some central committee who would send literature to their principals. State boards of education could be importuned to make biology a required subject. Both these schemes would eventually require more biology teachers.

(b) There is considerable demand for a good experiment book like we have in chemistry and physics; present-day workbooks are largely copybooks. Our association could publish one. Let each member send one or more of his favorite experiments to some central committee; these could be mimeographed and tried out by all interested. Eventually we could get them printed and possibly used by many members. The profits would give us a neat sum for expansion. Book companies must be reaping a harvest from the sale of manuals these days. Why not share in it?

J. L. SLOANAKER

The Use of Mnemonics as Aids in Biology Instruction

KENNETH B. M. CROOKS
Hampton Institute, Hampton, Virginia

The Problem

There seems to be a consensus among teachers of Biology that there are some weaknesses in the content and aims of our current courses, that there are many deficiencies in our teaching technique and that a goodly portion of our pupils are either not of the best intellectual timber, or are not sufficiently well prepared for the tasks they tackle. It is the purpose of this paper to contribute to our methods of instruction so as to assist our pupils, such as they are, to think more clearly, learn more readily and recall more effectively the information they are supposed to gain in our courses.

It is generally agreed that one of the aims of a high school or college course in Biology should be the formulation of a better way of life. But if our pupils cannot and do not recall the factual information and principles we teach, they cannot be expected to make the worthwhile changes they are supposed to make.

A Partial Solution

Though the phenomena of learning are thought to involve the establishment of so-called "stimulus-response bonds" in pupils' minds, we are confident that though this may be true in simple memorization processes, learning is not simple habit formation as this widely accepted view implies. Many writers have expressed this opinion. Understanding, appreciation, and associations seem to us learning methods which make for better retention, more effective integration, and more intelligent application. Accordingly, science teachers have been challenged to make pupils do reflective thinking. In our own case, we have been able to encourage reflective thinking and increase retention by the use of *mnemonics*.[1]

Some of the mnemonics mentioned below have been in my mind since school days; many have been so assimilated that I do not know their source. But most are, I believe, original, and swept into mind during the exigencies of actual teaching. A few are offered here in the hope that they might help science teachers and suggest methods of procedure.

The many mnemonics used successfully during the last few years fall into three general classes: (a) Mnemonics based on an understanding of the etymology of words; (b) Mnemonics based on association or correlations; and (c) Miscellaneous Mnemonics.

[1] A mnemonic may be defined as any method of aiding the memory. The values of mnemonics have been recognized since the days of the Ancients. Plato and Aristotle, and Cicero and Quintilian, devised and used complex mnemonic systems. Later, extensive and often elaborate systems have been developed by men whose names are well known to students of science, as Roger Bacon (died 1294), Giordano Bruno (died 1600), and more recently by H. Kothe (1852; 1857), Colegrove (1901), Roth (1918), Bruno Furst (1939), and others.

Mnemonics Based on Etymology

A fundamental appreciation of many English words is made easy by understanding the component parts and the meanings of Greek or Latin prefixes, roots, and suffixes. In science the debt to these parent languages is great.[2] The word *science* is itself derived from *scientia* (Latin), meanging *knowledge;* if a pupil understands this, the true significance of modern science becomes evident. If a youngster gets from his high school Latin, Greek, French, or Spanish no more than a vocabulary of prefixes, suffixes, and certain fundamental roots, he will have gained tools which enable him to use his native tongue much more lucidly and intelligently. And too, he will be better able to appreciate, and hence to recall, his scientific information. The accompanying tables are suggestive.

From a knowledge of etymology pupils find the word *aldehyde* derived from *al* (an abbreviation of alcohol), and *dehyde* (from Latin *dehydratus*). Since literally al-dehydratus means "dehydrated alcohol," there is a natural relation between the method of preparation of aldehydes, their chemical structure and the meaning of the word.

In a similar way the pupil learns and recalls readily the meanings of such words as *Hermaphrodite* (Hermes, the god Mercury (male), and Aphrodite, the goddess Venus (female)). *Paleontology* is derived from the Greek *palaios* —ancient, *ontos*—living things, and *logos*—study, discourse. There is mnemonic relation between the *pubis*, a bone, and *pubic* hairs, which arise on the anterior pubic area at the time of *puberty*. *Psychology* is derived from *psyche*, soul or mind, and *logos*. The examples in the tables show how the meanings of many common words as well as technical ones are derived and how their significance can be understood and recalled.

[2] It is interesting to note here, however, that high school pupils have as difficult a time with non-scientific English words as with purely scientific ones (Curtis '39).

Mnemonics from Associations and Correlations

It is commonly acknowledged that the most skillful teachers are those who depart from the beaten path of a text-book and wander into the wide area of human experiences, especially into those that are of real interest and are related to the material being studied. A good teacher searches far and wide for persons, places, facts, incidents, and human experiences of interest to pupils, including both their likes and dislikes. He draws freely on these for a flow of student interest. The breadth of a teacher's knowledge determines his ability to stimulate and maintain interest and hence indirectly, is a measure of his skill.[3] If teaching success is to be based on the pupil's ability to retain what he has learned with the teacher's help, then those teachers skillful enough to use the associations and correlations of human experiences and provide vicarious experiences should certainly be the most successful. The parables of Jesus, into the fabric of which he wove the precepts for which he stood, are excellent examples of how a skillful teacher can present abstract truth and principles so as to have them remembered. Jesus' parables are as stimulating today as they were 2000 years ago, and are still easy to remember.

Coincidences are always of interest.

[3] This is another reason why a teacher should be as in Goldsmith's poem, a person with a large fund of knowledge, instead of the type satirized in the well known quip: "He who can, does; he who cannot, teaches."

When I tell my pupils that both Abraham Lincoln and Charles Darwin were born in 1809 and that in the same year, too, J. B. Lamarck published his *Philosophie Zoölogique* they rarely forget the correlations between Lamarck's view of Evolution and Darwin's "Survival of the Fittest" theory. Both of these men set free men's minds from slavery to theological dogma just as the Great Emancipator freed from chattel slavery the bodies of millions of black folk. Again Darwin's theory was first set forth in his book *The Origin of Species* published 1859–60, and Negro pupils tie in and recall easily the fact that Booker T. Washington was born either 1859 or 1860.

THE SIMILARITY OF SOUNDS are also of value. Since the second syllable of *concave* suggests a cavity in the ground, concave is understood to be an "in" curve; conversely, *convex*, its opposite, is a bulge. When one discusses bicon-

TABLE I

PREFIXES FREQUENTLY MET WITH

Prefix	Meaning	Examples (including variations of Prefix)
Ana- Gr.	up	*Ana*-bolism; *ana*-phylaxis
Cata- Gr.	down	*Cata*-bolism (*Kata*-bolism)
Com- (cum) Lat.	with, together	*Co*-agulate; *col*-lect; *com*-mute *con*-nect; *cor*-rode; *coun*-cil
Di- Gr.	double	*Di*-lemma; *di*-genetic; *di*-oecious
Dia- Gr.	through	*Dia*-betes; *dia*-lysis
Di- Lat.	apart, away	*Dis*-sect; *di*-gest; *di*-late
En- Gr.	in	*En*-grave; *en*-cyst
Endo- Gr.	within	*Endo*-crine; *endo*-skeleton
Epi- Gr.	upon	*Epi*-dermis
Hetero- Gr.	other	*Hetero*-geneous
Holo- Gr.	entire	*Holo*-blastic; *holo*-caust
Homo- Gr.	same	*Homo*-geneous
Hyper- Gr.	above, beyond	*Hyper*-bole; *hyper*-trophy
Hypo- Gr.	below	*Hypo*-chrondriac; *hypo*-tenuse; *hypo*-thesis
Inter- Lat.	between	*Inter*-collegiate; *inter*-cellular
Intra- Lat.	within	*Intro*-mittent; *intra*-mural
Mal-, Male- Lat.	evil, bad	*Mal*-ignant; *mal*-aria
Meta-, Lat.	within, with, after, among	*Meta*-genesis; *meta*-bolism
Mono- Gr.	single, alone	*Mono*-tone; *mono*-graph
Multi- Lat.	many, much	*Multi*-cellular
Panto-, Pan- Gr.	all	*Pan*-theist; *panto*-morphic
Peri- Gr.	around	*Peri*-meter; *peri*-cardium
Poly- Gr.	many	*Poly*-gamist; *poly*-gon
Post- Lat.	after, behind	*Post*-erior
Pre- Lat.	before	*Pre*-vious; *pre*-molar; *pre*-natal
Pro- Lat.	instead; before	*Pro*-American; *pro*-test; *pro*-ceed; *prog*-nosis
Pseudo- Gr.	false	*Pseudo*-podium
Retro- Lat.	behind, backwards	*Retro*-gress; *retro*-version
Sub- Lat.	under	*Sub*-cutaneous
Semi- Lat.	one half	*Semi*-conscious
Super- Lat.	above, over	*Super*-human; *super*-ior
Syn- Gr.	with	*Syn*-arthrosis; *sym*-pathy; *syn*-apse
Trans- Lat.	across, through	*Trans*-parent; *trans*-Atlantic
Ultra- Lat.	beyond	*Ultra*-conservative; *ultra*-marine
Unus- Lat.	one	*Uni*-cellar

cave lenses in a physics or physiology lesson, there should then be no confusion.

In the convolutions of the mammalian brain are folds called *gyri* and *sulci*. The latter resembles *sulk* in sound; as one sulks when "down" in spirit, the sulci are remembered as the downfolds; hence, gyri are the up-folded portions of the convolutions.

"Humorous" Associations. The two phases of metabolism, anabolism and catabolism, are hard to forget when one imagines Anna, a girl, building a toy house of blocks. *Anabolism* is thus, the constructive phase of the living process. At the same time, her *cat* is busy pulling down the blocks; this represents *catabolism* (or katabolism), the destructive phase. The analogy can be carried further; if Anna works more rapidly than the cat, the house increases in size, *i.e.*, when anabolism exceeds catabolism, growth occurs. The reverse also follows.

Associations Involving Imagination. Imaginative pictures and analogies prove valuable in teaching new facts and in introducing new concepts. Few beginning students of the sciences appreciate the true magnitude of a microscope's powers. When they look into the instrument and see a *Paramecium* travelling at apparently express train speed, they often doubt that all they see is happening in the little drop of water on the slide. To indicate the significance of magnification we asked our pupils to determine the average time for several organisms to cross the circular microscopic field. From the measured size of the organism and of the distance travelled, the class calculation revealed that in spite of this speed, if a Paramecium kept going in a straight line, it would require eighty-eight hours (three and one half days) to travel one mile.

Analogies are good to explain the concepts of microscopic images. For example, cartilage (or gristle) is visualized as a block of ice (to represent the homogeneous, translucent matrix); in the ice we imagine many water-filled

TABLE II

Some Common Roots

English Words	Greek Roots	Latin Roots	Words Suggested
Life	Bios	Vita	Biology; Vitality*
Light	Photos, (Phos)	Lumen (Lux)	Photograph; Luminous
Health	Hygieia	Sanitas	Hygiene; Sanitary
White	Leukos	Albus	Leucocyte; Albino
Man	Anthropikos	Homo	Anthropoid; Homicide
Horse	Hippos	Equus	Hippopotamus; Equestrian; Equine
Black	Melas, Melanas	Niger, (Spanish Negro)	Melanocyte; Negro
Arms	Brachion	Brachium	Brachial (Muscles)
Head	Cephalon	Caput (Capit-)	Cephalic; Capital
Air (lung)	Pneuma (air)	Pulmo (lung)	Pneumonia; Pulmonary
Blood	Haimor (aima)	Sanguis, -inis	Hemorrhage; Sanguinary
Body	Soma	Corpus	Somatic, Somite; Corporal, Corpse, Corpuscle
First	Protos	Primus	Protoplasm, Protozoan, Protein; Primary
Skin	Derma	Pellis	Dermatologist; Pellicle
Poison	Toxicon	Virus	Toxin; Virulent

* In this list the first words are of Greek origin, the second, Latin.

cavities (*lacunae* containing *cartilage fluid* or *lymph*) and in the water of each cavity, peaches (*cartilage cells*), each with a central peach stone (the cartilage cell *nucleus*). After a pupil has seen models, pictures and the cartilage tissue through the microscope, an imaginative picture of this sort clears his thinking and the concept of gristle in three dimensions is no longer insurmountable. Similar imaginative pictures can help to explain other concepts and functions which involve facts and ideas new to the pupils.

Association with Other Knowledge —External Correlations. Correlation of new material with information already gained in other subjects or in hobbies, serves both to refresh the mind on the old material and also to supply good stimuli for recalling the new. Every boy or girl who has read detective stories will easily visualize a hinged trap door in the ceiling of a room. Attached to the underside is a strong rope just as long as the room is high so that though the trap door may let objects fall, it cannot be raised above the level of the ceiling. In such a picture one has a working model of a ventricle of the heart (the room), with the inelastic, tendinous cords (the rope) which hold the valves (the trap door) attached to the ventricle floor and prevent them from being forced up into the atrium (the attic above our ceiling). Thus, when the trap door (valve) fits well and the ropes (tendinous cords) are not too long or too weak, there will be no passage from the room up through the trap door. Hence, there will be no leaking valve and no defective heart action.

The similarities between a flame and a living body are well known, but often require two lessons. However, nearly all boys and an increasing number of girls already know the science of the internal combustion engine. It is thus easy to teach the analogies between the gasoline fuel and the food; the intake (ingestion) is followed by carburetion, by which the fuel is broken up into small particles and then vaporized so that it can be burned in the cylinder. This is similar to the food being chewed into small particles and then digested by enzymes to molecules which can be absorbed and "burned" (by metabolism) in the body tissues. The gasoline mixture needs air before it will explode in the engine; so too, oxygen from the respiratory organs and the blood is required to make metabolism possible. Finally, the spark which makes the explosion possible is likened to the insulin which enables absorbed carbohydrates to be oxidized. In both cases energy is produced as heat and motion, and the waste products, carbon monoxide, carbon dioxide, and water of the engine correspond to the metabolic end products excreted by the body. The unburned smoke of the exhaust is analogous to the unused, undigested food masses expelled from the digestive tract.

Miscellaneous Mnemonics

The old trick of using initial letters to remember items is so good that there is danger of its overuse, with the result that more effort is spent recalling the mnemonic than in the material to be remembered. In meeting many new students at once, I use a variety of schemes to recall their names by means of initials, but such are usually forgotten soon after they have served their purpose. In scientific matters, however, many initial-letter mnemonics have remained in mind and have repeatedly proved valuable.

In the mammalian eye, the Anterior chamber (initial letter A) contains the Aqueous humor; and A (aqueous

humor) in the alphabet comes before V (in the vitreous humor of the posterior chamber).

The initial letters of the three meninges of the central nervous system, *P*ia Mater, *A*rachnoid, *D*ura Mater named in their correct order from the inside out, spell PAD which also explains in part their function.

The names of the twelve Cranial nerves of mammals can be recalled from the jingle—

"*O*n *O*ld *O*lympus' *T*ipmost *T*op,
*A F*inn *A*nd *G*erman *P*icked *A H*op."[4]

The correct order of the categories used in biological classification (Taxonomy), which is difficult to appreciate and hard to remember when first met, offers no hardships even to a secondary pupil when the initial letters in their correct order are combined into the sentence—

"*S*ome *G*ood *F*olks *O*rder *C*hicken *P*ie," hence the correct taxonomic order, *S*pecies *G*enus *F*amily *O*rder *C*lass *P*hylum.

Thirteen essential elements in protoplasm are easily recalled when their symbols are arranged as follows—

C, H, O, P, K, I, N, S, Ca, Fe, Mg, Na, Cl;

"C. Hopkins' Cafe mighty good—
(if taken with a grain of salt)."

Using Jingles. Almost everyone has at some time or other whispered to himself:

"I before E except after C,"

but few know subsequent helpful lines, two of which are—

"And in words such as Weigh,
"Where they both sound like A."

Most of us recall the number of days in any month by the well known

"Thirty days hath September. . . ."

[4] These nerves are: Olfactory, Optic, Oculomotor, Trochlear, Trigeminus, Abducens, Facial, Auditory, Glossopharyngeal, Pneumogastric (Vagus), Accessory, and Hypoglossal.

Rhymes and jingles have the disadvantage of being sometimes misleading, as is evidenced by the man weak in Anatomy who on first meeting a Mr. Gummick, decided that the name rhymed with "stomach," yet greeted that gentleman some time later as Mr. Kelly. Thus, even the best tools may fail occasionally.

These few examples are given here to indicate that there are great possibilities for teachers with vision. The questions of the choice of the subject in our science courses and the background, interest, and future of our pupils are urgent. But facing the facts as they are, we must meet the challenge with imagination, and so vitalize our teaching that we help our pupils to recall more and more of the valuable things to which we are exposing them. Thus perhaps we may make our science teaching bear more fruit. We can; and we must; for as Emerson wrote, "The man who can make hard things easy is the real educator."

PERMANENT METAL LABELS

At Chicago Teachers College partially labelled demonstrations, especially of muscles, have been used in vertebrate anatomy to help students establish landmarks. These labels have been made with pencil or ink letters on small common cardboard tags which were then dipped into melted paraffin to coat them. The chief criticism is that of disintegration with use, particularly if subjected to moisture. Plastics in solution have also been used to cover the tags but the result is not entirely satisfactory, because of disintegration, discoloration, and finally, the necessity for making several successive applications, which is tedious. Even metal rimmed tags were

not without disadvantages, one being the electrolytic reaction with the lining of the copper wash boilers used for storage. Wooden tree-labels proved to be cumbrous, and the copper wire discolored the specimens.

Metal markers have been substituted. Several trials of different methods of making these were utilized. Thin sheets of soft metal were imprinted in a typewriter with the ribbon removed. This is rapid and has been done with both copper and aluminum. However, the thin strips bend out of shape with handling, and the clarity of the letters has been criticized. Stylus writing on thin metal was more legible. Letter dies of various sizes give sharp cleanly cut words and heavy gauges of metal may be used for the tag, but the process of stamping one letter at a time by hand is very slow. Specifications of die stamping machines were examined but the purchase of such a machine appeared to be an unjustified expenditure considering the infrequent use it might receive. Other methods were considered and rejected for one reason or another.

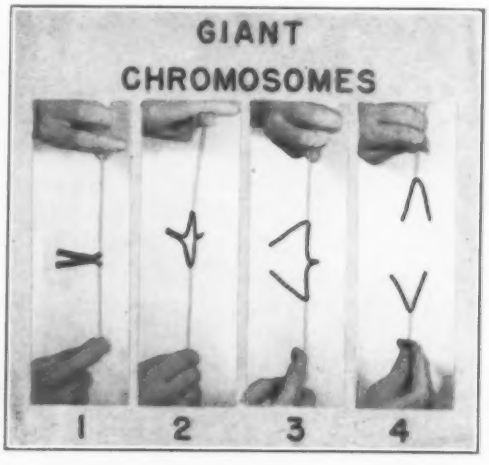
A Chicago firm (Denoyer-Geppert Co.) has experimented with our suggestion and has produced metal labels which are excellent. The words are clearly stamped on resistant metal and the letters are filled in with white lacquer. They are very legible and have withstood tests in preservatives. A set of standardized labels could be made for any laboratory animal and used over and over, or a generalized list might serve for any of several animals. A metal tag with square ends with one hole and stamped lacquered letters costs ten cents each (minimum order $2.00) or $4.50 for fifty, while another label with rounded ends and smoothed edges with a hole at either end sells for 20 cents each or $9.50 for a set of fifty.

These metal tags may be used for identifying museum specimens, laboratory displays, preserved material in collections where species are mixed, for marking animals collected in the field, for student guidance in demonstration dissections, for practical examinations, for class reviews. Tried as well as probable uses point to this as a method which is flexible and thus adaptable under many circumstances.

James M. Sanders,
Chicago Teachers College,
Chicago, Illinois.

GIANT CHROMOSOMES

It is often difficult to demonstrate convincingly to the average Biology class just how chromosomes split longitudinally during mitosis. The teacher of Biology must frequently wish that he had some giant chromosomes with which he could demonstrate this phase of cell division. Good charts or models, if available, will be very helpful, but experience has shown that the following simple method is much more effective. The main reason for its success lies in the fact that charts and models are stationary things which do not move, whereas this method actually performs the act of tearing apart the giant chromosome model. The



necessary material can usually be found in any laboratory, or can be purchased for a few cents, and the time and skill required to perform the demonstration is negligible.

The giant chromosome is really nothing more than a few inches of ordinary electric lamp cord, namely, the kind in which the two strands of wire are encased in a single rubber coat. The role of the spindle fibers is played by two pieces of very thin wire or stout thread, each about a foot long. With a scalpel, or preferably a pocket knife, a small slit is cut lengthwise in the rubber casing between the two parts of the electric wire, at the midpoint of the artificial chromosome. Through this slit the two pieces of thin wire or thread are passed, and one of them is securely fastened to each of the separated rubber coated wires. The giant chromosome should then be bent to form the characteristic V shape. Then by pulling on the two thin wires or threads, which act as spindle fibers, the rubber casing of the electric wire will easily tear in a manner very similar to the traditional splitting of a chromosome. The accompanying illustrations show four stages in the splitting of this giant chromosome.

Rev. John W. Baechle,
St. Joseph's College,
Collegeville, Indiana.

The Aquarium as a Teaching Device

JOHN BREUKELMAN
Kansas State Teachers College of Emporia

(Continued from January)

9. Locomotion

The pupil can spend a good deal of time watching the locomotion of animals in an aquarium; after he has observed the leech, compared the snail with planaria, noted such various insects as the water strider, back-swimmer, water boatman, whirligig beetle, diving beetle and mosquito wiggler, seen the way in which the rainbow darter uses its fins to climb over rocks and watched the swimming movements of the water snake, frog and turtle he cannot help but see the correlation of body form and type of movement. He will realize that different animals bring about the same type of movement with different body parts and that the same animal may have two or more distinct types of locomotion making use of different body parts.

10. Protection

By careful placing of rocks, sand and vegetation the aquarium can be so arranged as to bring out the protective coloration of the tadpole and the hiding behavior of the crayfish. The closing of the shell of the clam and turtle and the trapdoor of the snail can be observed at close range. And the student may himself give the stimulus that induces the protective response. Such weapons as the spines of many of the fishes, the jaws of the hellgramite and the claws of the crayfish can be seen in action. The use of speed to escape a predator can be observed in a large aquarium.

11. Learning

Fishes of some types can be taught to appear for feeding in a certain corner of the aquarium and in response to a certain signal. It is easy to observe that some species adjust themselves rather quickly to such a change in environment as a glass partition across the middle of the aquarium and that others merely continue to bump their noses against the glass. The change in general behavior after a period of captivity varies tremendously with different kinds of animals. Some fishes that are normally bottom feeders will learn to come to the surface for food; others will starve to death without learning. If a considerable number of specimens of the same species are taught to come for feeding on a certain signal, it will be observed that some individuals learn more quickly than others. Animals vary not only in making adjustments to artificial conditions, but also in forgetting them after the artificial conditions are removed. If the feeding signal is omitted for a week or ten days some fishes have to learn all over again.

12. Physical Factors of the Environment

There is no limit to the number and variety of experiments that may be devised to test the effects of light, temperature, chemicals and other non-living influences on the organisms in the aquarium. Temperature stratification may be produced by means of a partially submerged light bulb at the surface and an anchored piece of ice on the bottom. Many of the smaller organisms will orient themselves rather sharply in respect to such stratification. The effect of evaporation may be shown by covering one aquarium with a glass plate and leaving another uncovered. The former will usually be several degrees warmer. The oxygen content of the two can then be measured and thus several ecological factors studied in relation to each other. A stirring motor can be set up to produce a constant current through the aquarium, to illustrate responses of animals to running water. There is of course no limit to the chemical changes that can be made in the water. These can be correlated with studies of pollution and conservation.

13. Hydrogen-ion Concentration

Measurements of the hydrogen-ion concentration made at various times of day reveal many interesting relationships. The accumulation of carbonic acid during the night and the shortage of the acid after a day of photosynthesis can thus be checked. If a running water aquarium is available it is instructive to take frequent readings of the pH of the water as it comes out of the tap and compare it with that of the aquarium. Readings made in the field may be compared with those in the aquarium. Sometimes these differ widely. Some aquatic animals cannot stand a very abrupt change in hydrogen-ion concentration and may show various signs of distress when transferred from their habitat to the aquarium. Checking changes in pH resulting from addition of dilute acids and alkalis, salts, limestone and other substances offers opportunities for correlation with physical science.

14. Temperature Effects

We have used the aquarium for physiology experiments to study the effect of temperature changes on general activity, rate of respiratory movements, carbon dioxide production and feeding habits of fishes, locomotion rate of snails and planaria, growth of mosquito larvae, rate

of development of snail eggs, feeding activities of crayfishes, oxygen production of elodea and several other physiological activities. In some cases the responses are delicate enough so that the rate changes can be measured with considerable accuracy and the effect of temperature on rate compared with the corresponding effect in ordinary chemical reactions. The speed of locomotion of planaria is such a case. The construction of heating and cooling devices suggests correlation with physical science and industrial arts.

15. Balance and Unbalance

A balanced aquarium may be established in a gallon bottle. A few good oxygenating plants such as elodea and several small animals such as snails will live successfully, even with the bottle sealed, provided sudden temperature changes are avoided. In any aquarium that is approximately in balance, unbalance may be produced directly by the addition of new forms of animals in considerable numbers or of excessive numbers of forms already present. It may be produced indirectly by an abrupt change in temperature, the addition of chemicals, reduction in the amount of light or other changes in conditions favorable to some of the species present and unfavorable to others. Then the establishment of a new balance may be noted if the changes are not too drastic. Long time successions may also be noted. We have a ten gallon carboy aquarium which has not been disturbed, except for the addition of water to replace that lost by evaporation, since September, 1933. Since then there have occurred many cycles of scarcity and abundance of both plants and animals, as well as the building of more than an inch of "soil" above the bottom sand originally placed there.

16. Sanitation

A dead animal may be put into the aquarium, or one that dies left there, to illustrate the activity of molds, bacteria and other microorganisms or the action of scavengers, or both. Sometimes the scavengers will not be able to keep ahead of the microorganisms and decay results. Excess food will ferment and decay. Here are opportunities to correlate microscopic studies with ecological. If facilities are available pure cultures may be made of some of the organisms. Bacteriological tests are practical in some schools. There are many applications to the problems of water supply and sewage disposal.

17. Parasitism

We had at one time in the same aquarium a sunfish infested with "water mold" or white fungus, several minnows heavily infested with "fish lice," a small snapping turtle with about a dozen leeches on it and a number of fishes of various species carrying clam glochidia. We have observed several other examples of parasitism in the aquarium. The glochidia also illustrate the shift from the parasitic habit to the free-living state. If heavily infested fishes or crayfishes are kept in separate jars with uninfested specimens of the same species it is sometimes possible to observe some of the details of transfer and life history of the parasites.

18. The Marine Aquarium

It has in recent years become practical to ship the necessary materials for a marine aquarium to almost any point in the country. It is a rather expensive procedure for the extremely small schools, but even there in terms of total experience gained, on a per-pupil basis, it may be money well spent. It often

offers the only opportunity for pupils to see live starfish, sea urchins, sea anemones, hermit crabs, king crabs, sandworms, corals and the like. To the inlander the feeding of marine animals presents a whole new set of problems. The observation of a starfish feeding on a barnacle is worth considerable reading of printed material. Some comparison with related fresh water forms is of interest. Transfer from fresh to salt water and vice versa offers possibilities for experiments for those so inclined. The adaptability of different animals to mixtures of various percentages of fresh and salt water can be tested.

Biological Briefs

KAISER, ALBERT D. *Significance of the Tonsils in the Development of the Child.* Journal of the American Medical Association 115: 1151–1156. October 5, 1940.

The author of this article argues for a reduction in the numbers of unnecessary tonsillectomies performed on children. Where markedly hypertrophied tonsils persist after the age of four years, their removal is indicated, since repeated attacks of tonsillitis and adenitis impair physical development. Such a condition exists in no more than 20% of all children. Although it has been argued that tonsillectomies prevent frequent colds, sinusitis, and laryngitis, these statements have never been satisfactorily proved. Similarly, the tonsils do not appear to play any important role in the incidence of bronchitis, pneumonia, tuberculosis, rheumatic disease, or nephritis.

SHOUGH, W. WREN. *The Feeding of Ground Beetles.* The American Midland Naturalist 24: 336–344. September. 1940.

The ground beetles are largely predaceous in habit, but a few will eat other types of food. An abundant source for them is under freshly mown clover or alfalfa, where the insects feeding on the living plants are still present to serve as prey for the beetles. They may be kept in small containers with damp sand or moistened filter paper. A great variety of living forms were given to the beetles, and in most cases any insect which could be penetrated was quickly eaten. Some jumping insects were able to resist attack, while larval forms were the most helpless. Small beetles attack the larvae of insects bigger than themselves, if the prey is slow-moving. The slime of earthworms and slugs is unpleasant to them, but proves no deterrent if the beetles become extremely hungry. A few are plant feeders to some extent, and some in captivity accepted raw beef or cheese for food.

GRIGGS, ROBERT F. *Timberline on Mount Washington.* The New England Naturalist, No. 8: 11–16. September, 1940.

The reasons for the occurrence of scrub forests and of timberline on the heights of mountains are difficult to analyze. Temperature does not seem to play the strongest role, since the disappearance of trees cannot be clearly correlated with decreased temperature levels. Wind apparently is the most important factor, both directly by mechanical injury to the struggling plant, and indirectly by controlling the depth and deposition of snowdrifts. The marked increase of fogginess at higher levels must also play a part, since fog droplets clog the stomata and thus interfere with carbon dioxide intake.

RIPLEY, S. DILLON. *Wild Ducks for the Asking.* Natural History 46: 171–176, 186. October, 1940.

The hobby of keeping wild ducks is spreading, and can be started wherever a natural or artificial pond may be planted with shrubs and trees and protected from predators by a low fence. A nucleus of wing-clipped wild birds will soon attract others that will readily breed within the sanctuary. Wood ducks have been brought back almost from extinction largely by the efforts of one Connecticut man. New arrivals to a pond occasion considerable interest. Males are accepted readily; females are more aggressive and seem to be the ones which establish "peck order" in the flock. This order, whereby an individual may peck at certain birds at will but is in turn chased off by others, seems to be established upon the basis of bluff rather than of size.

RUTH SHERMAN

(*Continued from page 163*)

do not carry on some type of research or individual creative work. Some of these excuses are valid and perfectly understood, as when the nature of the problem is such that facilities, equipment, or material is not obtainable in the institution or region where one is teaching, or where there are other restrictions on the particular type of research.

The value of research to the average biologist is not so much that he will make outstanding discoveries or contributions to science, but that he will gain a great deal from the mental stimulation which comes as a result of creative or research activity. Research gives the worker an opportunity to utilize training and abilities along widely varied lines, and to acquire new skills. It gives him practice in some of the following: foreign language translation, experimentation, making and keeping collections, apparatus construction, keeping posted on the new and most recent literature of a special field, drawing techniques, analysis, organization and compilation of research data, and writing for publication. It makes one really appreciate science, and feel as if he belonged in the field, because only by participating fully and actively in a field does one gain enthusiasm and real appreciation of that field. Another very important thing that research does for one personally is that it places him directly in touch with a select group of widely scattered scientists who are either specialists or are vitally interested in that particular field. Not infrequently these workers exchange data, specimens, and observations; and suggest problems for further research. They may even collaborate.

Naturally, the teacher's first duty is to teach his subject well. His second duty is to make a definite, tangible contribution to his field, in the form of research or creative activity. He should not do one and disregard the other. The schools training science teachers could do a great service if they impressed this important fact on their students. However, in stressing research as a part of a teacher's duty to his field, schools and universities should guard against excessive pressure for published results because too often that stimulates the production of a large amount of written work which is of very mediocre grade and which can do considerable harm in that it clutters up scientific literature with data which never should have got into print. The emphasis should be on *quality* of research and reliability of one's data and experiments, rather than on a speedy turning out of research. The editorial policies of some journals which cause articles to remain "in storage" for about a year before they are published are not so bad after all, be-

cause this allows an author to withdraw an article before publication should experiments performed subsequent to the completion of the article negate his former data or cause him to change his mind.

Teaching Techniques

In addition to training in fundamental facts, principles, theories, laboratory techniques, and research, a prospective biology teacher needs training in biological teaching methods and techniques, methods of presentation of subject matter, construction of various types of tests, the evaluation and grading of student work, tricks dealing with the mechanics of class organization and order, seating, roll-taking, quiz conduction, handling of laboratory supplies (ordering, inventory, upkeep, storage), and the handling of students.

Above all, the future teacher should be taught critical scientific methods of thinking—how to think for himself. This can not be accomplished in one course, but must permeate every science course which he takes.

Another sometimes neglected item is that of making the prospective teacher understand that he must give his very best efforts and interest to the job. It really does not matter a great deal whether one is preparing to teach in a high school, junior college, or a regular college, because for any one of these the prospective candidate needs as much preparation or information and as many techniques as he possibly can get, plenty of common sense, a willingness to work earnestly and hard in his chosen field and a desire to get ahead.

Books

Bush, George L., Dickie, Allan, and Runkle, Ronald C. *A Biology of Familiar Things.* American Book Company. 695 pp. 1939. $1.92.

This is a pioneer text. It is not a text with a prescribed syllabus, with an encyclopedia approach, or with a highly integrated organization. It contains much less technical material than is found in many of the accepted modern textbooks. The stress is on consumer biology. Its true value can only be judged by careful use of the text by teachers and supervisors.

Mechanical Make-up: It is a 6 × 9 inch sturdy book with a brown and light tan cover arrangement. It features photographs, using a superbly executed "bled" engraving as an introduction to each unit. Its photography is exceedingly sharp and distinctive. There is a polychrome engraving as a frontispiece. Sufficient visual material, with effective introductory phrasing to legends, undoubtedly should stimulate closer examination of non-typographical matter. The typography is in a single column with well spaced composition. Especially effective is the composition of the overview to each unit. A unique development is the graphic illustration of laboratory techniques.

Psychological Soundness: In theory this book might be the essence of the psychological approach. It stems from central basic interests of the boy and the girl of our suburban communities. It appears to add to, supplement, and lead on from his or her everyday experiences. There is no evident seasonal arrangement. Paragraph headings are in the form of direct statements, viz., "It takes

little energy to sleep." "Sheep seldom have twins."

It is doubtful that there is a sufficient amount of worthy material present to make allowances for the brighter pupil. This is not a book for an academically minded student in high school.

Literary Style: Clarity of thought and expression is the keynote of the literary style of the text. The organization into levels where the simple style of presentation could be efficient is marked in many places. The approach, presentation, and statement of fact are decidedly above the average, and superior in many phases of the text's organization.

Sentence structure is in the main short and simple. The following is a selected example of a long sentence that is perfectly clear. "The microscope is also an aid to the proper treatment of cancer as it is possible to subject a small portion of abnormal tissue to high magnification by the use of the microscope, and in this manner to determine the rate of growth of the cancerous tissue and the effects of radium and x-rays used in the treatment."

The approach to a generalized subject such as "Plants for beauty and enjoyment" is further evidence of the mastery of the style of selection of facts in a really pleasing educational manner. In the unit on "Pets for pleasure and profit" the authors utilize every conventional pet to illustrate the laws and principles under consideration.

The literary style used by the authors is ably supported by visual aids of new and unusual selection. Their poignant appeal adds delight to the written discourse. A Biology of Familiar Things, has a pleasant, readable style with a minimum of "long words."

Subject Matter: The ten units emphasize five things: individual and community health; care of pets; cultivation of flowers; control of pests and of useful organisms; conservation of natural resources.

The book is unconventional. Some 300 pages are devoted to subjects generally not included in secondary school volumes. It leaves out a glossary, key to pronunciation, the cell theory, recapitulation, evolution, phylum mollusca, and the human skeleton. It treats mitosis, photosynthesis, somatogenesis, metabolism, interdependence, taxonomy, worms, echinodermata, and coelenterata briefly; reproduction quite fully.

Most of the criticisms are on details. Pages 407–8 are not explicit enough on finding hydra; pages 53 on bile, 56 on the manufacture of red corpuscles, and 58 on the heartbeat treat these too briefly for complete accuracy; page 58 omits the coronary circulation; pages 75, 76, and 79 cling to the stimulus-response-synapse theory discredited by Lashley of Harvard; page 78 presents the human instincts theory; some ductless glands are left out; page 111 gives vaccination blanket approval.

The final "Biology of the Future" unit might be too technical to make pupils realize that they can, without special college training, make real contributions to biology, as many people with a hobby are doing.

Despite these criticisms, this book is a fine piece of work, although everybody may not agree on the selection and relative emphasis of topics. It is an effort to present young people with a meaningful biology, and might serve as the first year of the two-year sequence in biological science recommended by the Committee on the Teaching of Science of the National Society for the Study of Education in its Thirty-first Year-book in 1932.

Learning Exercises and Teacher Helps: If one is looking for a biology

text book with a minimum of technical material, no dissection, and few experiments involving the use of apparatus, this text is the answer. In this book the technical terms are defined at their point of use, as, "Plants such as tall peas . . . which have both the tall and dwarf characteristics are called hybrids." This learning device is of great value to the student.

There are activities at the end of each phase of a unit to assist the teacher. These are divided into two groups: One for general class discussion, and the other for independent assignment and research. The latter may be used largely for the more capable members of the class. Very little experimentation is included in these activities. The assignments are rather elementary as they involve chiefly the looking up of factual material, as for example: "What is the significance of the tuberculosis stamps which are seen in the United States mail every Christmas?" or "Determine the specific dates for spraying for codling moth in your locality." Typical of the research assignments is "Investigate the cost of guaranteed moth proof furniture as compared to the ordinary variety." However, the supplementary material treated under the heading "sidelights" contributes several experiments such as methods of collecting insects (page 346). Exercises of this type offer an opportunity for development in recreational activities and hobbies. The bibliography at the end of each unit would be more valuable to both teacher and pupil if each reference were applied to specific aspects of the unit.

Since the aim of the authors admittedly is to present in a simple and informal way biological principles suitable to the needs of the average student, the learning activities and teacher aids included are sufficient.

ALAN A. NATHANS (*Chairman*)
ALVA Z. ALLEN (*New Hampshire*)
WILLIS W. COLLINS (*Oklahoma*)
MADELINE HERBERT (*Washington, D. C.*)

ZIM, HERBERT S. *Science Interests and Activities of Adolescents.* Ethical Culture Schools, New York. Lithoprinted. vii + 256 pp. 1940.

Science Interests and Activities of Adolescents is the report of a study begun in 1934 in connection with a research program of the Commission on Secondary School Curriculum of the Progressive Education Association. It consists of three parts and the Appendices.

Part one, in addition to a brief summary of previous work in the field and the methods of attack of the present study, presents data gathered from over three thousand boys and girls representing five different schools. The data were obtained by several methods, namely, the science interest questionnaire; analysis of compositions from 1171 pupils in English classes of the participating schools; a technique involving interests displayed in a science exhibit; the selection of films listed in a fictitious list of films corresponding to the areas of science included in the science exhibits; "Wondering Questions"; and from exhibits offered at the "Science Fair."

Part two is concerned with science interests from a more individualistic point of view, giving many interesting autobiographies and case histories.

Part three offers suggestions for both a program of study and the formation of a science curriculum for adolescents which bring out the practical application of the study. The curricular set-up of the five schools engaged in the study and

a good, brief bibliography for general books in the several pertinent fields are found in the Appendices.

Because of the large number of individuals concerned in the study and the many methods used in attacking the problem, the data present an especially interesting and important contribution to the field of science education. The science teacher who directs adolescent boys and girls should find the monograph of aid in understanding the attitudes of many of his pupils toward their science work. Those teachers or administrators interested in curriculum construction for this age group also might well consider the possibilities suggested by the data.

DOROTHY V. PHIPPS,
Chicago Teachers College,
Chicago, Illinois.

McMINN, HOWARD E., AND MAINO, EVELYN. *An Illustrated Manual of Pacific Coast Trees.* University of California Press, Berkeley, California. xii + 409 pp. 2nd ed., 1937. $3.50.

This book is more than a manual for the identification of the more commonly cultivated and native trees of California, Oregon, Washington, and British Columbia. It is a book that can be used with scientific accuracy by botanists or by nature lovers, as the authors have made the descriptions as nontechnical as possible without making a conscious effort to eliminate the more commonly used botanical terminology. The genera, under which are listed the species, are arranged alphabetically within the family and are based on vegetative characteristics for ease in using. The book is profusely illustrated.

Probably the most valuable part of the book for class or personal use is the short introduction on how to use the manual which includes adequate illustrated information on the names of the parts of a plant as well as a glossary of botanical terms.

In the back of the book is a 29 page list of trees recommended for various uses on the Pacific Coast, by H. W. Shepherd of the University of California, which includes information on alkali-tolerant trees, autumn-foliage-producing trees, avenue trees, border trees for home grounds, flowering trees, heat-tolerant trees, etc., with climatic recommendations and peculiarities.

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CHARLES C. HERBST,
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FIG. 164. Spring beauty *(Claytonia virginica)*

See Essentials of Biology pages 213–240, 547–604.

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(Smith, R. C., Jour. Ec. Ent. 31 (5): 564. N 11, 1938.)

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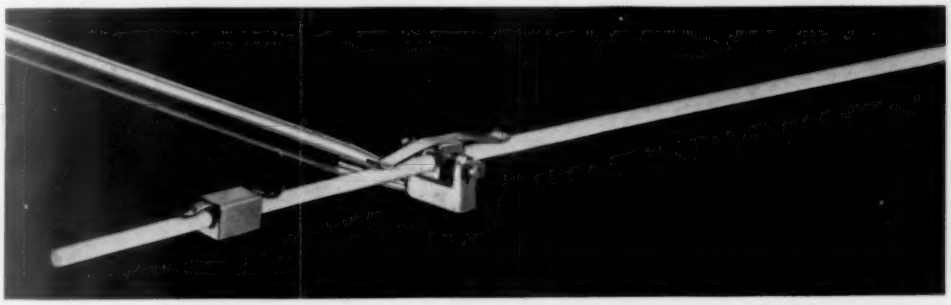

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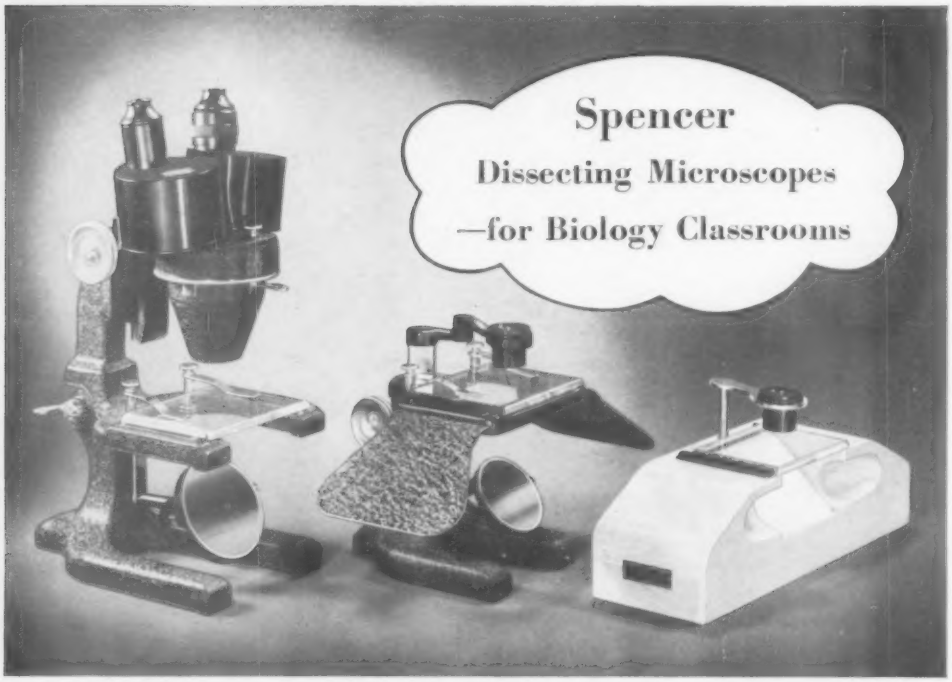

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